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U.S. Rural electrification administration.

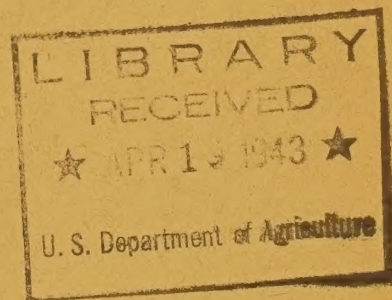
REA U.S. & LATIN AMERICAN ENGINEERING PROGRAM - CLASS OF 1942-43

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ELECTRIFICATION ACTIVITIES IN THE LATIN
AMERICAN REPUBLICS & PUERTO RICO

I. Puerto Rico Electrification Program

- A. The History and Development of the Puerto
Rican Electrification Program
Jose Cadilla EE
- B. The Operation of the Puerto Rican Electri-
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Rolando Franceschini

1943



GOVERNMENTAL ELECTRIFICATION IN PUERTO RICOPart I - History and Development of Program1. General Important Facts

Puerto Rico is the smallest and most easterly of the Greater Antilles located between latitude 17°52' and 18°37' North, and longitude 66°45' and 67°22' West. It is rectangular in shape approximately 100 miles long from East to West and 35 miles wide from North to South. It has an area of about 3,400 square miles with about 1,800,000 inhabitants. The island has two mountain chains which cross it, from east to west. They are slightly south of the center, the Sierra de Luguillo in the east, and Cordillera Central from east to west, with an approximate elevation of 4,000 feet above sea level. In general, there are three main formations in the island: (1) A central mountainous core of volcanic origin; (2) An elevated area of limestone surrounding the mountainous portion; and (3) The coastal plains. The central or mountainous region is well suited for the production of coffee and tobacco. The coastal plains formed by heavy deposits of alluvium brought from the highlands by rivers are very fertile, and especially adapted for sugar cane plantations. Sugar cane is the outstanding agricultural crop of the island. The northern coast plains have abundant rainfall, which makes them suitable for extensive cultivation of sugar cane. The southern coast plains, although fertile in their soil contents, have scanty rainfall which handicapped their use for sugar cane cultivation. These constituted a very serious problem which demanded an adequate and permanent solution.

2. Origin of Irrigation System

On September 18, 1908, the Legislative Body of Puerto Rico approved the Public Irrigation Law creating the Puerto Rico Irrigation System of the South Coast. By the approval of this bill, the insular government made feasible a collective and cooperative action of land owners for the irrigation of their fertile but dry farms. Studies began in 1908. Construction was started in 1910 and completed in 1914. The Puerto Rico Irrigation System is composed of four main storage reservoirs (Carite Reservoir, Patillas Reservoir, Guayabal Reservoir, and Coamo Reservoir) which receive their water supply from different sources and about 98 miles of main canals irrigating about 33,000 acres of land.

3. The Origin of Carite Plant, No. 1

The Carite Reservoir impounds the waters at the La Plata River. It is located in the mountains at an elevation of 1,783 feet (543.5 meters) above sea level with a storage capacity of 11,500,000 cubic meters. The La Plata River runs towards the northern coast and the water in the reservoir was passed towards the southern coast through a tunnel 3,060 feet in length. This water was led to the bed of the Guamani River and afterwards used for irrigation by a canal. It was found that there was a head of 1,105 feet fall available from the outlet of the Carite Tunnel to the foot of the mountain at the head of the Guamani River. Use of this available energy was considered by the government in order to provide energy at low rates for pumping installations of underground water for unserved farmers.

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In 1915 the Carite Hydro-electric Plant, No. 1, was built and placed in operation with an installed generating capacity of 700 KVA. The demand for power increased so rapidly that another unit of 700 KVA capacity was installed. This extension proved to be insufficient to meet the demand, and the Carite Plant No. 2 was built in 1922, with an installed capacity of 800 KVA. Further additions to Carite Plant No. 2 have been made, and at present it has 4200 KVA installed capacity.

The electrical energy produced by these plants is distributed in the irrigation service district. Nearly 85 per cent of it is used for driving irrigation pumps, and small industrial motors. The balance goes to supply lighting and domestic purposes in rural zones and nearby towns. Data of a recent year gives the total irrigation taxes paid by planters for a fiscal year as \$190,613.74, while the sale of electric power was \$400,000.00.

The development of the electric system in the Puerto Rico Irrigation System has helped to improve the financial structure of the system but its existence was not merely for the increasing of money revenues every year. A very important part of its program was the serving of unserved areas and to increase the usefulness of electric power by applying the lowest possible rates.

4. Utilization of the Water Resources

Guided by the experience in the operation of the Carite Hydro-electric System, in 1925 the Insular Government decided to work out a plan for enlarging its hydro-electric enterprises. The main objective of this plan was the use of its water resources to produce cheap electric power so as to encourage industries; the installation of ranges in houses to protect our forests; the control of floods of rivers; and the possible use for irrigation.

An act was passed by which a special tax of one-tenth of one per cent (1/10 of 1%) was levied on all real and personal property from 1925 to 1930. The money received was the working fund and authority was given for starting the surveys, construction and operation of hydro-electric plants. In 1927 this act was amended giving the administration more powers.

The organization created was called Utilization of the Water Resources. The first project developed was the Toro Negro Water Power Project. This project comprises the Guineo Dam and Reservoir, the Matrullas Dam, Reservoir and Canal, and the Toro Negro Hydro-electric Plant.

The Guineo Reservoir impounds the head waters of the Toro Negro River which flow toward the northern coast, with 1820 acres feet storage capacity, and at an elevation of 2960 feet above sea level. Water drawn from this reservoir flowed down the Toro Negro River to the inlet of Toro Negro Tunnel where joins the water coming from the Matrullas Dam.

The Matrullas Dam stores the water from the Matrullas River which flowed toward the northern coast and has a capacity of 3,000 acres feet at an elevation of 2415 feet above sea level. The water from this reservoir is conveyed through

the Matrullas Canal which is 33,224.3 feet long into the Toro Negro Tunnel where, together with the water coming from the Guineo Reservoir, it flows through the Toro Negro Tunnel, at an elevation of 2,226 feet above sea level. The water passing in the Toro Negro Tunnel flows towards the southern coast in this tunnel and afterwards meets the Aceituna Canal which is 10,000 feet long and drops through a steel penstock falling 1,650 feet to generate electric power at Toro Negro Hydro-electric Plant.

5. The Toro Negro Plant

The Toro Negro Hydro-electric Plant had an installed capacity of 6,000 H.P. formed by three water wheels and three direct connected generators of 5400 KVA total capacity. This project was completed in 1929 and has been in operation since then. One feature of this project is that the water used in this plant is later used on the Guayabal Reservoir for irrigation, thus increasing the basin which supplies water for this irrigation project.

Sooner than expected, the Toro Negro Plant was operating at full capacity due to the rapid increase in load. Further additions included the construction of Aceituna Forebay, the installment of a fourth unit of 5,400 KVA capacity at Toro Negro Plant No. 1, and the construction of Toro Negro Plant No. 2, with one unit of 2400 KVA capacity. In the Toro Negro Plant No. 2 the difference in head of Guineo Reservoir and Toro Negro Tunnel or 734 feet was used.

6. Expanding the Program

Inter-connections have been made with electric private utilities and with sugar mills. These inter-connections make enough available standby capacity in case any emergency arises in any system. At the same time it affords an opportunity of selling surplus energy badly needed by private utilities.

After 1931, the government acquired by purchase the distribution system of some cities. This purchase has been the result of the policy of the administration of giving an opportunity to urban areas to obtain electric power at our low rate schedules. The largest of these purchases was the Ponce Electric Company controlled by the Stone Webster Company, which operated a Steam Plant with an installed capacity of 4,063 KVA, and served the city of Ponce and nearby areas. The amount of this purchase was \$1,400,000. The last important acquisition was the Arecibo Plant and distribution system. This purchase gave the system more than 6,000 consumers and a hydro-electric plant of 900 KVA installed capacity and was made at the end of 1941.

Hydrographic surveys and investigations have been conducted continuously and systematically over a large portion of the island. With the data gathered from these surveys, plans have been prepared for a number of hydro-electric projects

The government's success in the operation of the Utilization of the Water Resources and Puerto Rico Irrigation Service has promoted the development of agriculture and industries, thus improving the people's living standards. The Federal Administration, in sympathy with its aims and purpose, has helped materially through the Reconstruction Program for Puerto Rico by the construction of rural lines, and providing funds for the construction of several of

these projects. Under this program there was completed the extensions of Toro Negro No. 1; construction of Toro Negro No. 2; construction of Carite No. 3; and construction of Garzas Hydro-electric Project and Dos Bocas Hydro-electric Project which are already working, although not at the rated capacity.

7. The Puerto Rico Water Resources Authority Act

On May 2, 1941 the Governor of Puerto Rico signed the "Puerto Rico Water Resources Act" No. 83, passed by the Insular Legislature creating the Puerto Rico Water Resources Authority. On October 29, 1941, 90 days after the bill was signed, all properties and functions of the Utilization of the Water Resources were transferred to the Puerto Rico Water Resources Authority. The Authority commenced operations with total assets of \$17,000,000, an indebtedness of \$1,500,000 and gross revenues of over one and one-half million dollars a year. It is estimated that after completion of property under construction, the Authority will be able to produce and sell more than twice as much power. This means that the estimated gross revenues will be \$2,500,000.

By additional provisions to Act No. 83, the Puerto Rico Water Resources Authority was given full power to acquire and operate aqueducts, in order to improve water facilities in cities. Since then, studies have been made of local conditions for the improvement of municipally-owned aqueducts in the island although none have been acquired yet. The Municipal Aqueduct of San Juan, the capital, is the one subjected to most studies because of its inability to serve its rapidly growing population.

8. Present Government Owned and Operating Plants

PLANTS	TYPE	No. of Units	ALTERNATORS		
			Capacity of Alternator Per Unit	Voltage Total KVA: in KV	
Carite No. 1	Hydro	3	700		
	"	1	2,100	4,200	2.3
Carite No. 2	"	1	800	800	2.3
Carite No. 3	"	1	800	800	2.3
Toro Negro No. 1	"	3	1,800		
	"	1	5,400	10,800	2.3
Toro Negro No. 2	"	1	2,400	2,400	2.3
Garzas No. 1	"	2	4,500	9,000	2.3
Garzas No. 2	"	1	6,300	6,300	2.3
Arecibo	"	2	450	900	2.3
Dos Bocas (In Constr.)	"	3	7,500	22,500	
				St- 57,700	
Ponce	Stearns	1	1,875		
	"	1	1,563		
	"	1	625	4,063	2.3
Total		22		61,763	

9. Federal Works Administration Program

In July 1942, the Federal Works Administration making use of the President's wartime power, acquired two electric private utilities which were given to the Puerto Rico Water Resources Authority to operate. These two electric private utilities were the Puerto Rico Railway, Light & Power Company, a Canadian concern with 31,350 KVA installed capacity. It was serving 700,000 persons in San Juan and the northeastern section of the island. The second one was the Mayaguez Light, Power & Ice Company native owned, 5,000 KVA installed capacity serving 65,000 persons in the southwestern section. The primary purpose of the Federal Government is the integration of these systems - mostly oil burning steam plants - with the government-owned hydro-electric plants. This integration of systems will permit the transfer of hydro-generated power into these systems, thus reducing the oil demand in the island, and at the same time offering a better and more dependable source of energy. The acquisition of these properties was endorsed by the Governor of Puerto Rico, Hon. Rexford Guy Tugwell, and by the Secretary of the Interior, Mr. Ickes. Title of property by the government was obtained by establishing in court a fair estimated valuation of \$7,250,000.

Recently acquired, installed capacity in plants operated by the government is:

Previous Owner	Plants	Type	Units	Capacity	ALTERNATORS	
					of Alternators	
					in KVA:	Voltage
					Per Unit	: Total KVA : in KV
P. R. Railway, Light & Power Co.	Comerio No.1 Hydro		2	500		
	"		1	1,000	2,000	2.3
	Comerio No.2		2	2,000	4,000	2.3
	Rio Blanco		2	3,125	6,250	2.3
					ST 12,250	
	Santurce	Steam	1	7,500		
	"	"	1	5,000		
	"	"	1	3,800		
	"	"	1	1,600		
	"	"	1	1,200	19,100	2.3
			12		ST 31,350	
Mayaguez Light, Power & Ice Co.	Mayaguez	Steam	2	2,500	5,000	2.3
			14		T 36,350	

Total installed capacity owned and operated by the government is 98,113 KVA which is broken into 69,950 KVA of Hydro-plant capacity and 28,163 KVA Steam-plant capacity.

The dams owned and operated by the government vary in their construction, being: (1) Earth dams filled with stone facing; (2) Earth dams with reinforced concrete core wall in the center; (3) Hollow reinforced concrete dams; and (4) Solid concrete dams. The design and construction of all projects has been done by native engineers, helped by outstanding consultant engineer of the United States of America.

10. The Management Today

The Puerto Rico Irrigation System and the Puerto Rico Water Resources Authority had come into existence to satisfy a need of the people of Puerto Rico rendering a service badly needed by the development of the water resources of the island. Since the beginning they have worked as sister organizations because of the dependence of each other and as a convenience for fulfilling its final aim. Later, by law, a consolidation was made of both systems to operate under a unified management and technical direction being under Mr. Antonio Lucchetti the Executive Director and Chief Engineer. Although both systems operate under unified management, separate accounting records are kept for each one. All administration expenses and services received in common are pro-rated according to their respective share of work actually accomplished.

The general headquarters for both systems are established in Guayama, head of a district in the southern coast, the center of territory originally operated. The management organization of both systems is composed in the following major divisions:

1. Executive Office

The executive office is the office of Mr. Antonio Lucchetti, Executive Director and Chief Engineer. It has the responsibility of supervising all other divisions, solving all major legal problems, preparation and execution of further developments and methods of financing them.

2. Division of Property and Accounts

This office takes care of all bookkeeping, preauditing of all bills payable, keeping of all personnel records, preparation of employee payrolls, credit and disbursement vouchers, purchase requisitions, all matters related with procurement of materials and supplies, operation of warehouses and transportation problems.

3. Commercial and Service Division

This office takes care of all billing and collection of consumers' accounts. Consumers' bills are prepared by the International Business Machines Corporation punch card methods. Rates problems are handled by this office.

4. Production and Distribution Division

This office takes care of all construction and operating electrical problems of power plants, substations, transmission lines, distribution lines, distribution systems and services, and systems communication lines.

5. Division of Engineering, Construction and Shops

This office takes care of solving general engineering problems of new developments and those arising in the operation of existing projects. Through its mechanics and shops it keeps systems operating in good mechanical condition constantly, and handles all automobile and truck repairs.

6. Irrigation and Hydrographic Division

This office takes care of all irrigation problems and operation. All hydrographic investigation and surveys are under its direct control. It makes preliminary studies and final plans of new developments.

